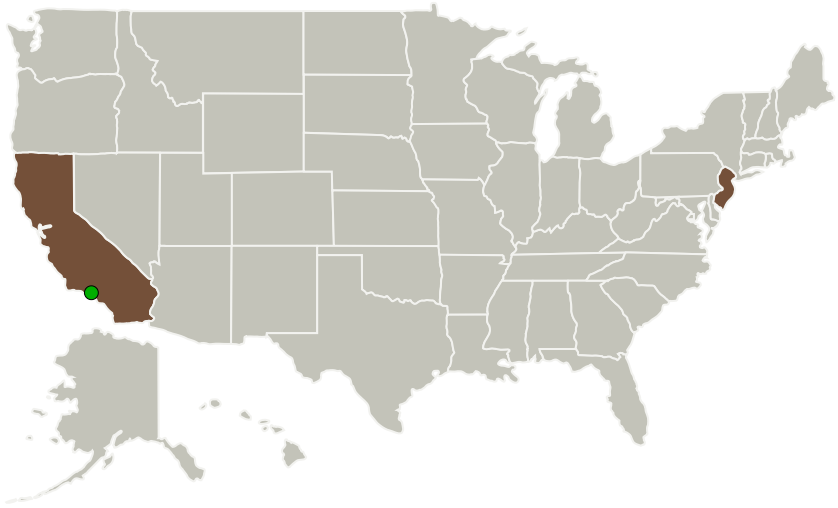
NFAD Arrays for Single Photon Optical Communications at 1.5 um, Phase II

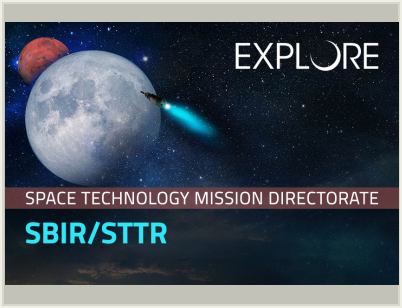
Completed Technology Project (2011 - 2013)

Project Introduction

For this program, we propose to develop large pixel-count single photon counting detector arrays suitable for deployment in spacecraft terminal receivers supporting long-range laser communication systems at 1.5 um. To surmount the present obstacles to higher photon counting rate -- as well as the complexity of back-end circuitry required -- in using conventional single photon avalanche diodes (SPADs), we will leverage initial success in monolithically integrating "negative feedback" elements with state-of-the-art SPADs to beneficially modify the device avalanche dynamics. This approach can achieve extremely consistent passive quenching, and appropriate implementations can lead to rather small avalanches (e.g., ~10^4 ↔ 10^5 carriers), for which reduced carrier trapping provides lower afterpulsing that will no longer limit the photon counting rate. When correctly implemented, this "negative feedback" avalanche diode (NFAD) design is also extremely simple to operate: with just a fixed dc bias voltage, the NFAD will autonomously execute the entire arm, avalanche, quench, and re-arm cycle and generate an output pulse every time an avalanche event is induced. During Phase 1 of this program, we characterized 5 different discrete NFAD designs to identify specific pixel-level design opportunities for reducing afterpulsing and timing jitter. We also fabricated and characterized wafer-level test structures that show excellent feedback element yield and uniformity sufficient for large-format NFAD arrays. These proofs-of-feasibility from Phase 1 position us to demonstrate space-qualifiable large pixel-count 128 x 128 NFAD arrays during a Phase 2 effort. This effort will also include the development of appropriate test platforms for NFAD array packaging and characterization.

Primary U.S. Work Locations and Key Partners





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Organizations Performing Work	Role	Type	Location
Princeton Lightwave, Inc.	Lead Organization	Industry	Cranbury, New Jersey
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
California	New Jersey

Project Transitions

June 2011: Project Start

September 2013: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/139166)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Princeton Lightwave, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:

Mark A Itzler

Co-Investigator:

Mark Itzler

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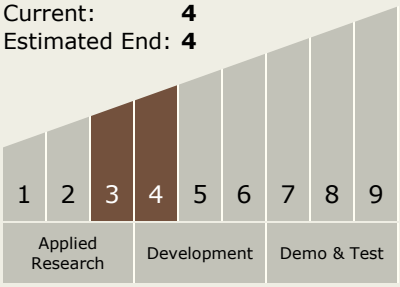
Completed Technology Project (2011 - 2013)

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.1 Optical Communications
    - TX05.1.1 Detector Development

Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System